

A repetition of the same process with the 23 per cent. of oxygen would have raised the percentage about 60 per cent., or a stronger concentration could have been reached by fractionating the gas as it slowly leaves the charcoal on gradually increasing the temperature.

This preliminary investigation suggests many fields for further inquiry, and some of these I hope to deal with in future papers.

I have to express my thanks to Mr. Robert Lennox, F.C.S., for efficient aid in the conduct of the experiments, and Mr. J. W. Heath, F.C.S., has also rendered valuable assistance.

“The Separation of the most Volatile Gases from Air without Liquefaction.” By Sir JAMES DEWAR, M.A., D.Sc., LL.D., F.R.S., Jacksonian Professor, University of Cambridge, and Fullerian Professor, Royal Institution, London. Received June 15,—Read June 16, 1904.

From the time when liquid air came to be an ordinary laboratory agent, I have continually used it for the purpose of producing high vacuums in vessels that had been previously filled with easily condensable gases, such as sulphurous acid, carbonic acid, vapour of water or benzol.

When the liquefaction of hydrogen was effected one of the first scientific uses to which it was put was that described in my paper on the “Application of Liquid Hydrogen to the Production of High Vacua, together with their Spectroscopic Examination.”* In that communication it was shown by theory and confirmed by experiment that the condensing power of liquid hydrogen is so great relatively to that of liquid oxygen or nitrogen, that any closed vessel, a part of which is cooled to the boiling point of hydrogen must suddenly become a highly vacuous space. This was proved by the great difficulty of getting electric discharges to pass through specially prepared spectroscopic tubes when subjected to liquid hydrogen cooling, and from the fact that when the current did pass no lines of oxygen or nitrogen were seen, but only those of hydrogen, helium and neon. In order to separate these latter gases from air it was necessary to liquefy a quantity of air and to distil off the most volatile portion at as low a temperature as possible into a separate receiver placed in liquid hydrogen. In this way many spectroscopic tubes were filled with the uncondensable air gases and the results of their examination is recorded in a paper entitled “On the Spectra of the more Volatile Gases of Atmospheric Air, which are not Condensed at the Temperature of Liquid Hydrogen,”† by Professor Liveing and myself.

* ‘Roy. Soc. Proc.,’ vol. 64, 1898.

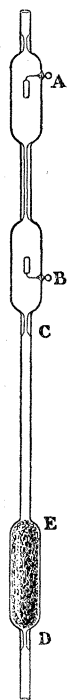
† ‘Roy. Soc. Proc.,’ vol. 67, 1900.

Some 2 years later I improved the method of separation of the volatile air gases. The process is fully described and illustrated in my paper on "Problems of the Atmosphere."* Its success depends upon the continuous direct liquefaction of air at atmospheric pressure combined with a device which enables the more volatile gases to be trapped and separated. In this way some $1/35,000$ th of the volume of the air liquefied is collected as a gaseous mixture, having the composition 38 per cent. of nitrogen, 4 per cent. of hydrogen, and 58 per cent. of mixed helium and neon. After sparking to remove the nitrogen and hydrogen, a gaseous mixture of helium and neon containing a little argon was obtained. This mixture had the composition of 16 per cent. helium and 84 per cent. neon. In both methods of treatment it will be noted the liquefaction of the air was the essential preliminary operation, to be supplemented in the one case by the use of liquid hydrogen, in the other by sparking to remove the nitrogen. The paper already communicated to the Royal Society, entitled "The Absorption and

Thermal Evolution of Gases Occluded in Charcoal at Low Temperatures," in which the greatly increased power of occlusion possessed by charcoal at low temperatures is proved, suggested an inquiry into the limits of gaseous pressure reached by such means of condensation.

With this object a narrow tube CE, fig. 1, was sealed to an ordinary spectroscopic sparking tube AB, and at the end E an enlarged space was blown out capable of holding a few grammes of cocoanut charcoal. After the charcoal had been freed from gases by heating and exhaustion and the poles cleared by sparking during this operation, pure and dry gases like oxygen, nitrogen, air, carbonic oxide, hydrogen, neon and helium could be admitted at different pressures and the tube with its charcoal chamber attached sealed off.

On placing the charcoal end of the apparatus in liquid air the gas in each case was rapidly absorbed and the vacuum produced reached the phosphorescent stage in all cases with the exception of hydrogen, neon, and helium. A small Crookes's radiometer, full of air at atmospheric pressure, with charcoal tube attached, became quite active to heat radiation when the charcoal was cooled for half a minute in liquid air. To test the amount of exhaustion reached by the use of a given weight of cocoanut charcoal I sealed on a tube containing 30 grammes to a large electric discharge tube of 1300 c.c. capacity filled with air at atmospheric pressure. On cooling the charcoal receptacle in liquid air the pressure diminished to 50 mm. of mercury. Repeating the same experiment but starting with the tube initially at half an atmosphere, the exhaustion reached was



* 'Roy. Inst. Proc.,' 1902.

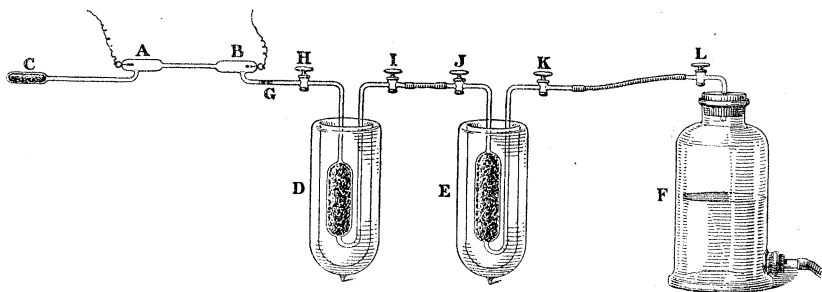
now beyond the striæ stage. A further experiment starting with one-fourth of an atmosphere gave a vacuum through which no discharge passed.

Finally, the 30 grammes of charcoal were replaced by only 1 gramme and the initial pressure was reduced to 3 mm. of mercury. Now the vacuum just reached the beginning of the phosphorescent stage. With hydrogen, either a pressure of gas less than that of the atmosphere had to be used at starting or a larger amount of charcoal employed in order to get a vacuum well up in the striæ stage. If, however, the liquid air was cooled to -210° C. by exhaustion, the tube just reached the beginning of phosphorescence round the cathodes.

With helium there was a very slight absorption, but neon did show something more appreciably. Spectroscopic observations made during the condensation of the gas in the charcoal showed the gradual disappearance of the characteristic spectrum of oxygen, nitrogen and air, as the high vacuum was reached and the discharge passed with great difficulty. In tubes of this kind filled at atmospheric pressure I could always see the F line of hydrogen and the neon yellow; but the helium was not seen with any definiteness. As the amount of neon in the air cannot well exceed 1/50,000th, the spectroscopic test is very delicate.

In order to bring in the helium lines it was necessary to concentrate the volume of air in the space of the sparking tube six or seven times. This was done by the use of an arrangement shown in fig. 2. A B is

FIG. 2.



the sparking tube with its small charcoal bulb C attached, capable of being sealed off when required at G; and D and E are larger charcoal absorbers placed in vacuum tubes containing liquid air; the whole being attached to a graduated gas-holder containing air. A series of glass stop-cocks are attached at the points H, I, J and K in order to facilitate manipulation. In determining the volume of air required to bring in the helium lines only one charcoal absorber containing about 15 grammes of material was used. On allowing 200 c.c. of air from the gas holder to be sucked into the charcoal (which had been previously

exhausted along with the sparking tube), on opening the stop-cock H any residuary gas in D was swept into the sparking tube, which was then sealed off at G.

This tube gave the hydrogen lines C and F, the neon yellow, and some of the orange lines, along with the helium yellow and green quite distinct. With the residuary gas extracted from 1 litre of air I could see all the helium lines. On the positive pole the neon yellow and the green of helium were alone marked, while the negative pole gave both the neon and helium yellow lines along with the helium green and the F of hydrogen on the continuous spectrum. From this it would appear that the spectroscopic test for helium is as delicate as that for neon, and that 1/50,000th can be recognised. From 3 litres of air discharge tubes were obtained giving the neon and helium spectra associated with a brilliant ruddy glow discharge.

As 40—50 grammes of charcoal can absorb at the temperature of liquid air from 5—6 litres, it is easy to accumulate rapidly the undensified gases in considerable quantities for spectroscopic examination. For this purpose I found it convenient to use two charcoal condensers in circuit as represented in fig. 2. After the charcoal in the first one marked E was saturated, the stop-cock K was closed, while I and J were opened for a short time so as to allow the less condensable gas in E to be sucked into the second vessel of the same type D along with some portion of air. The charcoal condenser E was then taken out of the liquid air, and rapidly heated to 15° C. in order to expel the occluded air. It was thus in a condition to repeat the absorption. In this way 50 litres of air can be treated in a short time. Sparking tubes filled from the accumulated gases in D were very brilliant, showing the complete spectrum of the volatile constituents of air. It is hardly necessary to remark that after the little charcoal receptacle connected to each of the sparking tubes has been cooled and thus all traces of air absorbed, it can be sealed off, leaving the spectroscopic tubes intact. The complete spectroscopic study of the products must be left for further examination with Professor Living.

The method I have described will be equally applicable to the treatment of the gaseous products from minerals containing helium, hydrogen, etc., and also to the radium products of a similar kind. It seems even probable that the separation of the less volatile constituents in air may be improved by a slight modification in the mode of working. The behaviour of the gases from the Bath Springs has been examined. When the gas containing 1/1000th part of helium in what may be regarded as pure nitrogen is subjected to charcoal absorption exactly in the same way as the air was treated no high vacuum is reached. All the nitrogen and any other constituents disappear, and a spectrum of helium and hydrogen showing much less neon than exists in the volatile residue from atmospheric air is the result. A sample of

argon made from Bath gas gave, when the argon was absorbed in charcoal, a gas residuum giving the helium and neon spectrum, and the same result follows the use of atmospheric argon. In the case, however, of the Bath gas argon the helium spectrum is the stronger, whereas with air argon the neon is the most pronounced.

In order to further test the method, the crude gases got by heating the mineral Fergusonite were examined. During the cooling of the charcoal the nitrogen and hydrogen spectra were marked, but in a short time nothing could be seen but the lines of hydrogen and helium.

Great interest will attach to the behaviour of helium, hydrogen and the most volatile part of air, when subjected to the action of charcoal cooled to the temperature of liquid hydrogen. The method promises to open up many avenues for future inquiry.

I am indebted to Mr. Robert Lennox, F.C.S., for efficient assistance in the conduct of the experiments, and Mr. J. W. Heath, F.C.S., has also helped me in the investigation.

“On the Action of Wood on a Photographic Plate in the Dark.”

By WILLIAM J. RUSSELL, Ph.D., F.R.S. Received May 28.—

Read June 16, 1904.

(Abstract.)

[PLATE 7.]

It has been shown in former papers that many substances are capable of acting on a photographic plate in the dark and producing a picture of themselves. Further investigation shows that this property belongs probably to all woods, some, however, being much more active than others.

To obtain a picture the wood has to be in contact or at a little distance above the photographic plate, and has to remain there for times varying from $\frac{1}{2}$ an hour to 18 hours, and to be at a temperature not higher than 55° C.

The wood of the conifers is very active, and gives pictures which are very definite. Fig. 1 is a picture of a section of a branch of a Scotch fir, and shows well the rings of spring and autumn growth. It is remarkable that the former are very active, producing in this picture the dark rings, and so with the other pictures, the part which is active in the original is dark in the picture. The rings seen in the wood are very sharp and strongly pronounced in the picture. If the action exerted on the plate be owing to the presence of hydrogen peroxide, as has been previously suggested, no doubt it is produced

FIG. 1.

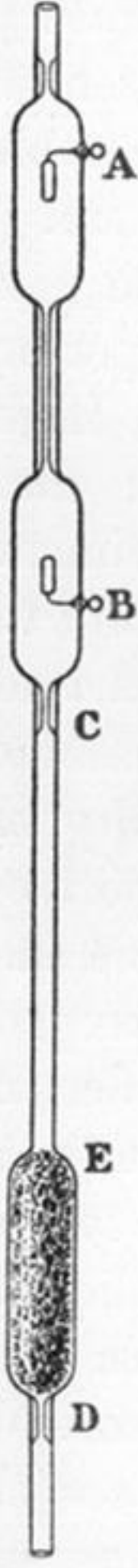


FIG. 2.

